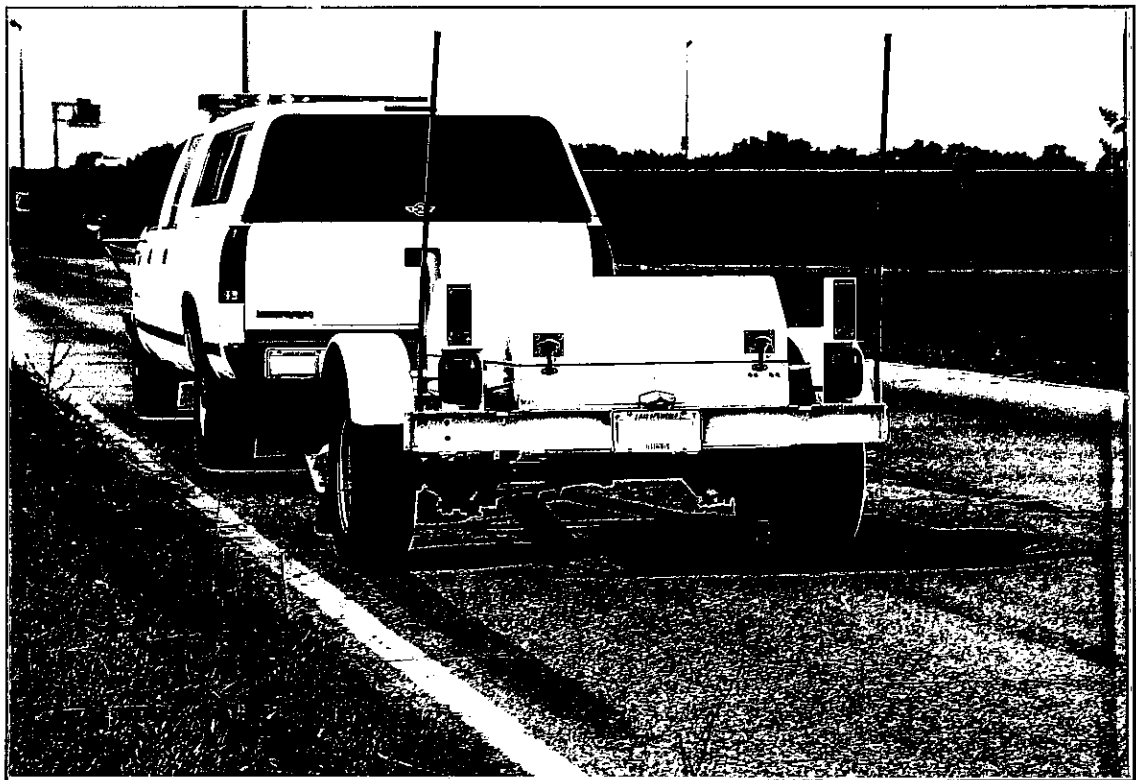


# **FRICTION QUALITIES OF VARIOUS PCC PAVEMENT TEXTURES**

**Summary of Friction Testing on Interstate 72,  
East of Springfield, Illinois**



**PHYSICAL RESEARCH REPORT NO. 135  
MARCH 2000**



**Illinois Department of Transportation**  
Bureau of Materials and Physical Research  
126 E. Ash Street / Springfield, Illinois / 62704-4766

# **FRICTION QUALITIES OF VARIOUS PCC PAVEMENT TEXTURES**

**Summary of Friction Testing on Interstate 72,  
East of Springfield, Illinois**



**PHYSICAL RESEARCH REPORT NO. 135  
MARCH 2000**



**Illinois Department of Transportation**  
Bureau of Materials and Physical Research  
126 E. Ash Street / Springfield, Illinois / 62704-4766

1. Report No. IL-PRR-135	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle FRICTION QUALITIES OF VARIOUS PCC PAVEMENT TEXTURES SUMMARY OF FRICTION TESTING ON INTERSTATE-72, EAST OF SPRINGFIELD, IL		5. Report Date March 2000	
		6. Performing Organization Code	
7. Author(s) Tessa H. Volle		8. Performing Organization Report No. Physical Research No. 135	
9. Performing Organization Name and Address  Illinois Department of Transportation Bureau of Materials and Physical Research 126 East Ash Street Springfield, Illinois 62704-4766		10. Work Unit (TRAIS)	
		11. Contract or Grant No.  IHR - R07	
12. Sponsoring Agency Name and Address  Illinois Department of Transportation Bureau of Materials and Physical Research 126 East Ash Street Springfield, Illinois 62704-4766		13. Type of Report and Period Covered  Final Report August 1976 - August 1997	
		14. Sponsoring Agency Code	
15. Supplementary Notes			
16. Abstract  <p>In August 1976, a continuously reinforced concrete pavement (CRCP) project on Interstate-72, east of Springfield, Illinois, was textured with various pieces of equipment mounted to a texturing/curing machine. The project was divided into the following seven sections of textures: transverse tine, transverse broom, artificial turf, transverse roller, artificial turf and transverse tine combination, longitudinal tine, and longitudinal broom. From October 1976 to October 1979 (36 months), a testing program was conducted to collect the following measurements: friction numbers, speed gradient, texture depth, internal and external vehicle noise level, and pavement smoothness. In August 1997, friction numbers were again measured on the I-72 experimental sections just before the surface was overlaid with bituminous surface course. This report compares the results of the friction tests during the years that the pavement was tested.</p> <p>According to the departmental guidelines for friction numbers, all the textures were found to perform within acceptable parameters. The combination of the artificial turf and transverse tines, or the Type A final finish, should continue to be a departmental standard for texturing PCC pavement surfaces in areas of higher speed limits (over 40 mph). The Type A final finish is also recommended as a PCC pavement texture in areas of high friction demand, such as intersections and other areas where stop and go traffic is prevalent.</p>			
17. Key Words  PCC pavement, friction, texture, friction number, test sequence		18. Distribution Statement  No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 44	22. Price

# **FRICTION QUALITIES OF VARIOUS PCC PAVEMENT TEXTURES**

Summary of Friction Testing on Interstate-72,  
East of Springfield, Illinois

By:

Tessa H. Volle  
Materials Investigations Engineer

Illinois Department of Transportation  
Bureau of Materials and Physical Research  
Springfield, Illinois 62704

March 2000

## TABLE OF CONTENTS

Acknowledgments and Disclaimer .....	iv
Executive Summary .....	v
List of Tables .....	vii
List of Figures .....	viii
Introduction .....	1
Background .....	1
Testing Program .....	1
Friction Test Results .....	3
Discussion of Data .....	4
Relative Ratings of Average Friction Numbers .....	4
Analysis of Results .....	7
Summary and Conclusions .....	15
Recommendations .....	17
References .....	18
Appendix A - Texture Descriptions and Measurements .....	19
Appendix B - Friction Testing Data 1976 - 1997 .....	21
Appendix C - 1997 Detailed Friction Testing Data .....	26
Appendix D - Figures D1 - D4: Friction Test Results .....	30
Appendix E - Traffic Data for I-72 (1976 - 1997) .....	35

## **ACKNOWLEDGEMENTS**

Testing was performed by the Operations Unit of the Pavement Technology Unit. Report review was completed by James DuBose, David Lippert, Brian Pfeifer, LaDonna Rowden, Amy Schutzbach, and Jeffrey South.

## **DISCLAIMER**

The content of this report reflects the views of the author, who is responsible for the facts and accuracy of the data presented herein. The content does not necessarily reflect the official views or policies of the Illinois Department of Transportation. This report does not constitute a standard, specification, or regulation.

## EXECUTIVE SUMMARY

In August 1976, a continuously reinforced concrete pavement (CRCP) project on Interstate-72, east of Springfield, Illinois, was finished with the following seven textures: transverse tines, transverse broom, artificial turf, transverse roller, artificial turf and transverse tines combination, longitudinal tines, and longitudinal broom. During a 36-month period from October 1976 to October 1979, a testing program was conducted to collect the following measurements: friction number, speed gradient, texture depth, internal and external vehicle noise level, and pavement smoothness. In August 1997, friction numbers were again measured on the same textured sections. The purpose of this report is to compare and evaluate the friction numbers collected in 1976 – 1979 and in 1997.

The microtexture of a pavement refers to the fine-scale roughness in the surface. Macrotexture in concrete pavement is defined as the measurable deeper striations or grooves formed in plastic concrete during finishing. While the treaded tire has been found in many research studies to be insensitive to macrotexture, the smooth tire has shown considerably more sensitivity to macrotexture. The smooth tire is more sensitive to the slight variations in the macrotexture of different textures (i.e. tining versus brooming) due to its inability to channel water.

The following conclusions are made from the friction testing completed on I-72:

1. The artificial turf and transverse tines section was consistently found to have higher friction measurements throughout the testing program.
2. The transversely and longitudinally tined sections were found to have average friction numbers slightly lower than the numbers for the artificial turf and transversely tined section.
3. Throughout the testing program, the transverse broom, the longitudinal broom, the artificial turf, and the transverse roller sections were frequently found to have lower average friction numbers than the tined sections.
4. According to the Department's Categorical Rating Guidelines for Friction Numbers, the average friction numbers for the seven experimental textures fell within ranges that did not indicate friction as a likely factor in wet weather accidents.

Currently, the Department specifies two types of final finishes for Portland cement concrete (PCC) pavements. The Type A final finish is a combination of the artificial turf and transverse tines; the

Type B finish is the artificial turf alone. The Type A finish is to be used unless the Type B finish is specified. According to Departmental Policies, the Type A final finish is to be used on highways with posted speed limits in excess of 40 mph (64 kmph). The Type A or the Type B final finish is to be used on highways with posted speed limits not exceeding 40 mph (64 kmph).

According to the findings of this testing program, recommendations regarding the specifications and policies are as follows:

1. The Type A final finish, the combination of the artificial turf and transverse tines, provides increased and consistent friction measurements. The Type A finish should continue to be the standard for texturing PCC pavement surfaces in areas of higher speed limits (over 40 mph). According to friction test results presented in this report, the Type A finish, as compared to the Type B finish, improved smooth tire friction numbers by an average of over 120% at speeds of at least 40 mph (64 kmph).
2. The Type A final finish would also be excellent in areas of high friction demand, such as intersections and other areas where stop and go traffic is prevalent.

Even at 30 mph (48 kmph), the Type A finish (compared to the Type B finish) was found to increase smooth tire friction numbers by an average of 75%. Although the artificial turf and transversely tined texture is the best choice for good friction qualities, all the tined sections provided increased friction. According to data presented in this report, any of the tined textures (compared to the Type B finish) provided an increase in smooth tire friction numbers of 63% at 30 mph (48 kmph), 96% at 40 mph (64 kmph), and 127% at 50 mph (80 kmph). If the Department is seeking to provide the highest skid resistance and safety for vehicles traveling state roadways in Illinois, any one of the tined textures provided increased friction compared to the Type B finish. However, according to the current Department guidelines for friction numbers, the friction numbers for the Type B finish are acceptable. In order to implement any changes regarding the Department's standard policy on PCC pavement finishes, some important issues (i.e. cost and noise) need to be addressed. Those issues are outside the scope of this report.



## LIST OF TABLES

Table 1. I-72 Textures and Locations .....	1
Table 2. Treaded Tire Friction Test Results for 40 mph (64 kmph).....	3
Table 3. Smooth Tire Friction Test Results for 40 mph (64 kmph).....	3
Table 4. Ranking of Treaded Tire Friction Test Results for 40 mph (64 kmph).....	4
Table 5. Ranking of Smooth Tire Friction Test Results for 40 mph (64 kmph).....	5
Table 6. Categorical Rating Guidelines for Friction Numbers .....	14

## LIST OF FIGURES

Figure 1. Treaded Tire Friction Test Results for 40 mph (64 kmph) Driving Lane .....	7
Figure 2. Smooth Tire Friction Test Results for 40 mph (64 kmph) Driving Lane .....	7
Figure 3. Treaded Tire Friction Test Results for October 1979, Driving Lane .....	12
Figure 4. Smooth Tire Friction Test Results for October 1979, Driving Lane .....	13
Figure D-1. Treaded Tire Friction Test Results for 40 mph (64 kmph) Passing Lane .....	32
Figure D-2. Smooth Tire Friction Test Results for 40 mph (64 kmph) Passing Lane .....	32
Figure D-3. Treaded Tire Friction Test Results for 30 mph (48 kmph) Driving Lane .....	34
Figure D-4. Treaded Tire Friction Test Results for 50 mph (80 kmph) Driving Lane .....	34

## INTRODUCTION

### Background

In August 1976, seven of the most innovative and promising textured surfaces used in Illinois and other states were applied to a continuously reinforced concrete pavement (CRCP) project on Interstate-72, east of Springfield, Illinois. Prior to the initial setting of the concrete (within 1½ hours of concrete placement), the pavement was textured with various pieces of equipment mounted to a texturing/curing machine. The seven texture methods, locations, and total length of each test section are shown in Table 1. Appendix A contains descriptions and dimensions (depth, spacing, etc.) of the seven textures. The segments of textured pavement were constructed between two interchanges in order to maintain equivalent Average Daily Traffic (ADT) for all segments.

**Table 1**  
**I-72 Textures and Locations**

Section	Texture	Direction	Station Limits	Length of Segments
1	Transverse Tines	Eastbound	114+22 ~ 165+85	5163 ft (1574 m)
2	Transverse Broom	Eastbound	165+85 ~ 191+25	2540 ft (774 m)
3	Artificial Turf	Eastbound	203+05 ~ 236+98	3393 ft (1034 m)
4	Transverse Roller	Eastbound	236+98 ~ 248+59	1161 ft (354 m)
5	Artificial Turf & Transverse Tines	Westbound	203+15 ~ 227+80	2465 ft (751 m)
6	Longitudinal Broom	Westbound	176+22 ~ 191+74	1552 ft (473 m)
7	Longitudinal Tines	Westbound	104+37 ~ 176+22	7185 ft (2190 m)

### Testing Program

A testing program followed within two months after the paving project was completed and included the following measurements: friction number, speed gradient, texture depth, internal and external vehicle noise level, and pavement smoothness [1]. During a 36-month period from October 1976 to October 1979, friction numbers were measured seven times [2]. The noise level, texture depth, and pavement smoothness were also tested several times throughout the 36-month period. In August 1997, a follow-up testing program was conducted exclusively for measuring the friction

numbers of the textured sections. The purpose of this report is to compare and evaluate the friction numbers collected in 1976 - 1979 and in 1997.

Friction testing was conducted according to ASTM E 274. In 1976 and 1977, friction numbers were collected in the left wheel path using a treaded tire. For the testing completed after 1977, friction numbers were measured with a treaded tire in the left wheel path and a smooth tire in the right wheel path. For all of the testing performed before 1997, friction numbers were recorded at 30, 40, and 50 mph (48, 64, and 80 kmph). However, in 1997 friction numbers were obtained at 40 mph (64 kmph) only. Furthermore, data was recorded for the passing lane as well as the driving lane for all test dates except October 1976 and August 1997.

## FRICTION TEST RESULTS

The average friction numbers at 40 mph (64 kmph) obtained in the driving lane are summarized in Table 2 for the treaded tire and Table 3 for the smooth tire. Average friction numbers measured in both the driving and passing lanes and at all three testing speeds are included in Appendix B. More data from the testing completed in August 1997 are located in Appendix C. Refer to Table 1 for the textures corresponding to the designated section numbers at the top of each column in Tables 2 and 3.

**Table 2**  
**Treaded Tire Friction Numbers**  
**for 40 mph (64 kmph)**  
**Driving Lane**

Dates of Tests	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7
10-5-76	65	61	55	32	71	52	53
7-18-77	56	53	48	46	62	49	54
10-24-77	61	59	52	54	64	57	58
4-24/25-78	56	52	51	51	56	49	53
10-10-78	54	51	49	51	54	53	52
7-6-79	56	52	50	53	57	53	59
10-19-79	53	49	49	51	53	50	55
8-13-97	54	54	51	53	57	48	58

**Table 3**  
**Smooth Tire Friction Numbers**  
**for 40 mph (64 kmph)**  
**Driving Lane**

Dates of Tests	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7
4-24/25-78	45	21	23	32	51	23	36
10-10-78	39	19	21	27	48	21	40
7-6-79	43	27	27	35	54	28	49
10-19-79	41	21	21	28	46	23	41
8-13-97	36	23	20	31	48	24	38

## DISCUSSION OF DATA

### Relative Ratings of Average Friction Numbers

See Table 4 for the relative ratings of the average treaded tire friction numbers for each textured section and Table 5 for the average smooth tire friction number ratings. While treaded tire data was collected throughout the testing program (1976 - 1997), smooth tire data was only collected after 1977. Therefore, eight sets of treaded tire friction numbers and five sets of smooth tire friction numbers were available for interpretation and comparison in this report. The rankings range from number one (representing the highest average friction number of the seven textures) to number seven (representing the lowest average friction number). Again, refer to Table 1 for the textures corresponding to the designated section numbers at the top of each column in Tables 4 and 5.

In several of the test sequences, two or more of the textures had equivalent average friction numbers. Consequently, those textures received equivalent ratings. For example, in the April 1978 testing, both the artificial turf (Section 3) and the transverse roller (Section 4) textures had an average treaded tire friction number of 51. Therefore, both of the textures received a ranking of 5. The longitudinal broom texture (Section 6) had the next lowest average treaded tire friction number and received a ranking of 7.

**Table 4**  
**Ranking of Treaded Tire Friction Numbers**  
**for 40 mph (64 kmph)**  
**Driving Lane**

Dates of Tests	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7
10-5-76	2	3	4	7	1	6	5
7-18-77	2	4	6	7	1	5	3
10-24-77	2	3	7	6	1	5	4
4-24/25-78	1	4	5	5	1	7	3
10-10-78	1	5	7	5	1	3	4
7-6-79	3	6	7	4	2	4	1
10-19-79	2	6	6	4	2	5	1
8-13-97	2	4	6	5	2	7	1

**Table 5**  
**Ranking of Smooth Tire Friction Numbers**  
**for 40 mph (64 kmph)**  
**Driving Lane**

Dates of Tests	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7
4-24/25-78	2	7	5	4	1	5	3
10-10-78	3	7	5	4	1	5	2
7-6-79	3	6	6	4	1	5	2
10-19-79	2	6	6	4	1	5	2
8-13-97	3	6	7	4	1	5	2

***Transverse Tines (Section 1)***

The average treaded tire friction number rankings for the transversely tined section ranged from second highest to third highest every year except 1978. In the April and October 1978 friction tests, the average treaded tire friction numbers for the transversely tined section were ranked first along with the artificial turf with transverse tines section. The average smooth tire friction number rankings for the transversely tined section ranged from second highest to third highest in all the test sequences.

***Transverse Broom (Section 2)***

The average treaded tire friction numbers for the transverse broom section ranged from third to fourth highest during 1976 - 1978 and in 1997. However, in 1979, the friction numbers were ranked second lowest in the July friction test and lowest in the October friction test. The average smooth tire friction numbers for the transverse broom section were ranked lowest in each test sequence, except in 1997, when the average smooth tire friction number ranked second lowest.

***Artificial Turf (Section 3)***

The artificial turf texture was found to have relatively low treaded and smooth tire friction numbers throughout the 36-month testing period between 1976 and 1979 and again in 1997. The treaded tire friction numbers decreased after the first test sequence, when the average friction number was fourth lowest. In the remaining tests, the ranking was either lowest or second lowest. The average smooth tire friction numbers dropped from second lowest in 1976 - 1978 to lowest in 1979 and 1997.

#### ***Transverse Roller (Section 4)***

The transverse roller section was also found to have consistently low average friction numbers. However, its status as compared to the other textures improved over time. The average treaded tire friction numbers improved from lowest in October 1976 and July 1977 to second lowest in October 1977 - October 1978. Then the rankings improved from second to third lowest between October 1978 and July 1979 and remained at third lowest through the rest of the testing program. The average smooth tire friction numbers were third lowest in 1978 - 1979 but improved slightly to fourth lowest in 1997. As a note of interest, the Bureau of Materials and Physical Research received a number of complaints about the noise produced from driving on the transverse roller section. It was not unusual for drivers to pull off the road and check their cars after driving on this section. Signs stating "experimental pavement" were then placed near this section to prevent further confusion.

#### ***Artificial Turf and Transverse Tines (Section 5)***

Until 1979, the artificial turf with transverse tines texture was ranked highest of all textures in average treaded tire friction numbers. Then in the test sequences completed in 1979 and 1997, the average treaded tire friction numbers were found to be second highest. The average smooth tire friction numbers were highest in all test sequences.

#### ***Longitudinal Broom (Section 6)***

Except for the testing done in October 1978, the average treaded tire friction numbers for the longitudinal broom section were found to fluctuate between lowest and third lowest. However, the unusual results of the October 1978 test showed the average treaded tire friction number ranked third highest. The average smooth tire friction numbers fluctuated between second lowest and third lowest throughout the testing program.

#### ***Longitudinal Tines (Section 7)***

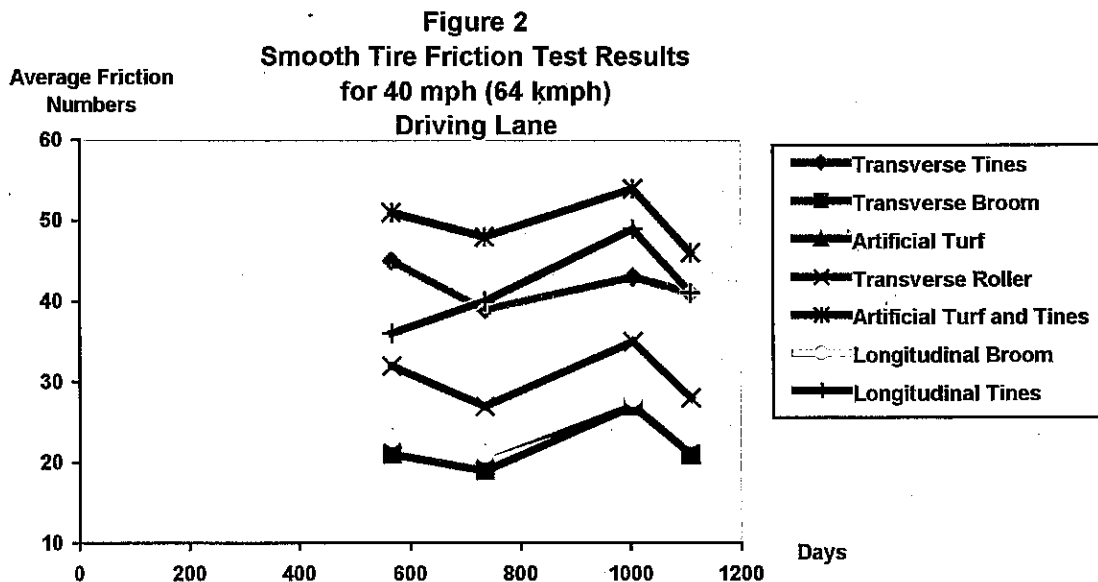
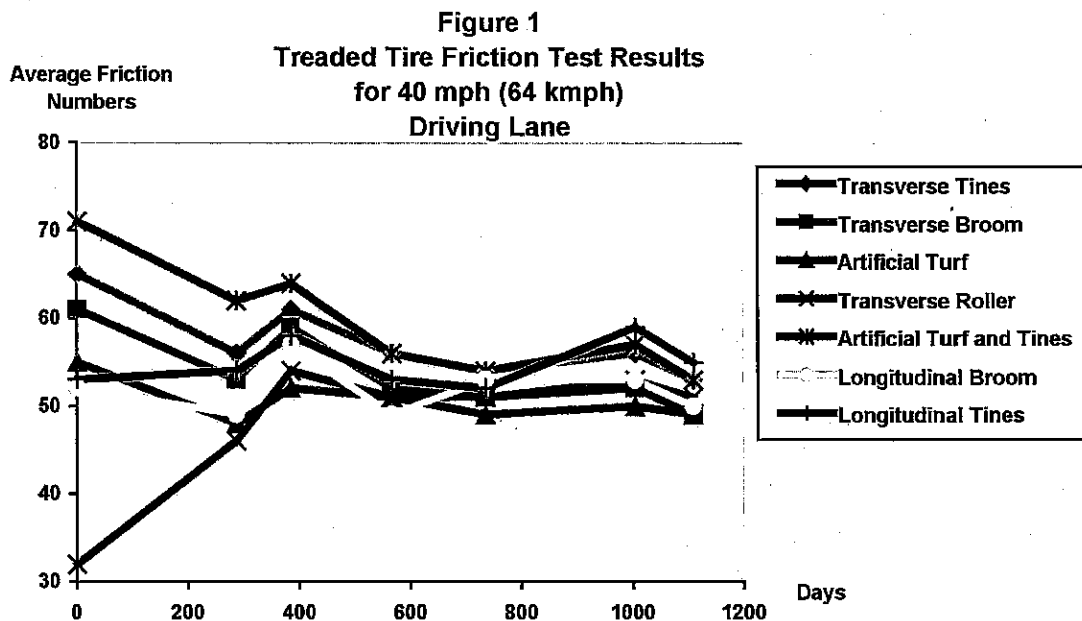
The average treaded tire friction numbers for the longitudinally tined section were the highest at the end of the 36-month testing period in July and October 1979 and also in August 1997. However, the numbers fluctuated between fifth and second highest during 1976 - 1978. The average smooth tire friction numbers for the longitudinal tines section ranged from third highest in April 1978 to second highest in every test sequence thereafter.



## Analysis of Results

### *Trends in friction numbers for treaded and smooth tires*

Graphical representations of the average friction numbers for each date of testing except August 1997 are presented in Figures 1 and 2. Other graphs of average friction numbers for the driving lane and the passing lane and for different speeds are included in Appendix D. Day 0 in Figures 1 and 2 is the first day of friction testing (treaded tire only), approximately two months after paving ended.



### ***1997 Friction Test Data***

Testing data for August 1997 (Day 7618) is not included in Figures 1 and 2 due to the 18-year gap between the friction test in October 1979 and the test in August 1997. If 1997 data were included in Figures 1 and 2, the trends represented in the graphs would be difficult to interpret due to the very wide range of data on the x-axes.

Overall, no dramatic changes occurred in the friction test results between October 1979 and August 1997. While the average treaded tire friction number dropped slightly for the longitudinal broom texture between 1979 and 1997, average treaded tire friction numbers increased slightly for all other textures. Average smooth tire friction numbers measured on the transverse tines, artificial turf, and longitudinal tines textures dropped slightly between 1979 and 1997; average smooth tire friction numbers increased for the other textures.

### ***Stabilization of Average Treaded Tire Friction Numbers***

As seen in Figure 1, the friction numbers stabilized about a year after the paving project was completed. The decrease in variability between the friction numbers of the different textures could be attributed to the changes in the macrotexture and especially the microtexture of the surfaces over time. "Microtexture of concrete pavement refers to fine-scale roughness contributed by individual asperities of aggregate particles (sand) in the mortar, while macrotexture is defined as the measurable deeper striations or grooves formed in the plastic concrete during the finishing, or the shallow grooves cut in the hardened pavement" [3]. The most significant decrease in variability occurred within the first year of testing. The sample standard deviation of the average treaded tire friction numbers decreased from 12.5 to 5.5 between October 1976 and July 1977; after July 1977, the sample standard deviation only varied between 1.8 and 4.1 for each testing date.

According to several studies, pavement surfaces are subjected to wearing and polishing under traffic. In a study on tining depth documented in Transportation Research Record No. 836, the following statement was made: "New pavements reportedly wore rapidly but stabilized after about 2 million passes of traffic. At that point, the microtexture had been worn away to a certain degree, while the macrotexture of the surface was still adequate" [4]. During the first year after the project was completed, the average daily traffic (ADT) was approximately 7,100 vehicles. The total traffic

for that year, calculated from the ADT, was over 2.5 million. Traffic data, such as equivalent single axle loads (ESALs), average daily traffic (ADT), and average daily truck traffic (ADTT), is included in Appendix E for each year between 1976 and 1997.

### ***Treaded Tire versus Smooth Tire***

The treaded and smooth tire friction numbers were significantly different in range. After 1977, the average treaded tire friction numbers fluctuated between a low of 48 and a high of 59, a range of only 11. On the other hand, the average smooth tire friction numbers varied from 19 to 54, a range of 35. While the treaded tire has been found in many research studies to be insensitive to macrotexture, the smooth tire has shown considerably more sensitivity to macrotexture. The smooth tire does not provide the drainage capabilities that the deep grooves of the treaded tire provide. Consequently, the smooth tire is more sensitive to slight variations in the macrotexture of different textures due to its inability to channel water [5].

Evidence of the greater sensitivity of the smooth tire to the microtexture and macrotexture can be seen in Figure 2. The surfaces that provide only microtexture and essentially no macrotexture (the sections finished with the artificial turf or the broom) had relatively low average smooth tire friction numbers (20 - 30). The tined sections had higher average smooth tire friction numbers (35 - 55); and the average smooth tire friction numbers for the transverse roller section fell between the smooth tire friction numbers for the other textures (25 - 35).

### ***Tining textures versus the artificial turf, broom, and roller finishes***

The average treaded tire friction numbers for the artificial turf with transverse tines texture were consistently the highest or second highest during the testing period. Furthermore, the average smooth tire friction numbers for that section were highest in every test sequence. While the longitudinally tined section was found to have higher treaded tire friction numbers in the last three test sequences (including August 1997), the artificial turf with transverse tines texture was generally higher in friction measurements throughout the testing program.

Compared with friction test results for the other textures, the artificial turf, the longitudinal broom, and the transverse broom sections were found to be less reliable in friction measurements. Of those three textures, the artificial turf texture was ranked lowest in average treaded tire friction numbers most often; the transverse broom section was ranked lowest most often in average

smooth tire friction numbers. In the last six test sequences (including August 1997), the average treaded tire friction numbers for the sections without tining were usually not much lower than the friction numbers for the tined sections. However, the average smooth tire friction numbers for those sections were lower than the tined sections in nearly all the test sequences. Based on the evidence that the smooth tire is more sensitive to macrotexture than the treaded tire, one can safely conclude that the tined sections provided improved macrotexture compared to the other sections.

The average friction numbers for the transverse roller section were higher in the end than the average friction numbers for the sections finished with the artificial turf or broom. However, average friction numbers for the transverse roller section were still lower than the average friction numbers for the tined sections.

According to the results of the smooth tire friction tests at 40 mph (64 kmph), the smooth tire friction numbers for the artificial turf with transverse tines section were an average of over 100% higher than the smooth tire friction numbers for the sections without tines. Furthermore, all of the tined sections were an average of 81% higher in smooth tire friction numbers than the sections that were not tined.

Currently, the Department specifies two types of final finishes for Portland cement concrete (PCC) pavements. The Type A final finish is a combination of the artificial turf and transverse tines; the Type B is the artificial turf alone. The Type A finish is to be used unless the Type B finish is specified [6]. According to Departmental Policies, the Type A final finish is to be used on highways with posted speed limits in excess of 40 mph (64 kmph). The Type A or the Type B final finish is to be used on highways with posted speed limits not exceeding 40 mph (64 kmph) [7].

Based on calculations made from friction test data presented in this report, the Type A finish or any tined texture provides increased friction measurements compared to the Type B finish. The Type A finish (compared to the Type B finish) was found to increase smooth tire friction numbers by an average of 75% at 30 mph (48 kmph), 122% at 40 mph (64 kmph), and 162% at 50 mph (80 kmph). In fact, all the tined textures (compared to the Type B finish) provided an average increase in smooth tire friction numbers of 63% at 30 mph (48 kmph), 96% at 40 mph (64 kmph), and 127% at 50 mph (80 kmph). In general, the transversely and longitudinally tined sections were

found to give the best results in both treaded and smooth tire friction numbers. Apparently, the use of the broom or the artificial turf alone is not as effective as the use of a tine rake (especially combined with the artificial turf) in creating textures with excellent friction qualities.

### ***Increasing Friction Numbers***

The longitudinally tined surface was predicted to maintain its friction qualities better than the other longitudinal finishes due to its relatively deeper texture [8]. Between some test sequences, the average friction numbers for the longitudinally tined texture increased. Generally, the longitudinally tined surface maintained its friction numbers over time, while most other textures had decreasing friction numbers. As a result, friction numbers for the longitudinally tined surface became comparable to friction numbers measured on other textures. In fact, average treaded tire friction numbers for the longitudinally tined surface were higher than all average treaded tire friction numbers in the last three test sequences.

The transverse roller section was the only other texture that was found to have increasing treaded tire friction numbers over the years, ranging from 32 in October 1976 to 53 in August 1997. The most drastic improvement was between October 1976 and October 1977, when the average treaded tire friction number increased from 32 to 54. After October 1977, the treaded tire friction numbers remained between 51 and 53. Because the average smooth tire friction numbers were only obtained after 1977, they had a small variance (between 27 and 35).

The initial low average treaded tire friction number for the transverse roller section could be a result of the steel-trowel-like finish created by the steel roller used to texture this section. However, as a result of the friction number increase, the friction measurements of the transverse roller section became comparable to the other sections over time. The increase in average treaded tire friction numbers could be attributed to the traffic wearing the surface and exposing the aggregate particles, thus creating an improved microtexture [9].

### ***Slight Variations of the Friction Numbers***

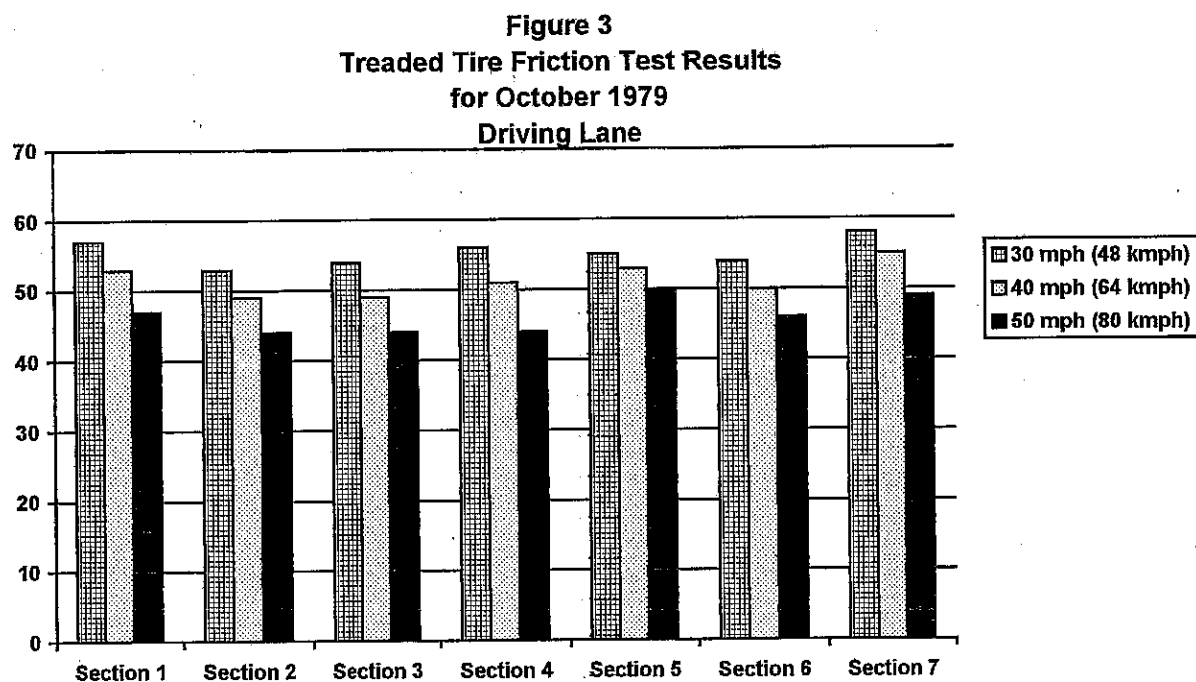
While the overall trends of the friction numbers have been explained, one might still question the slight fluctuations of the average friction numbers from one test sequence to another. The most likely cause of the variations is test error, but other factors may influence the results of the friction tests. For example, one may have observed that after 1977 the average treaded and smooth tire

friction numbers seemed to be slightly higher in the spring and summer months than in the fall months. According to several studies on factors influencing pavement friction, seasonal variation in friction numbers is not unusual. Several factors are listed below that might produce the small variations in the pavement friction test results [10].

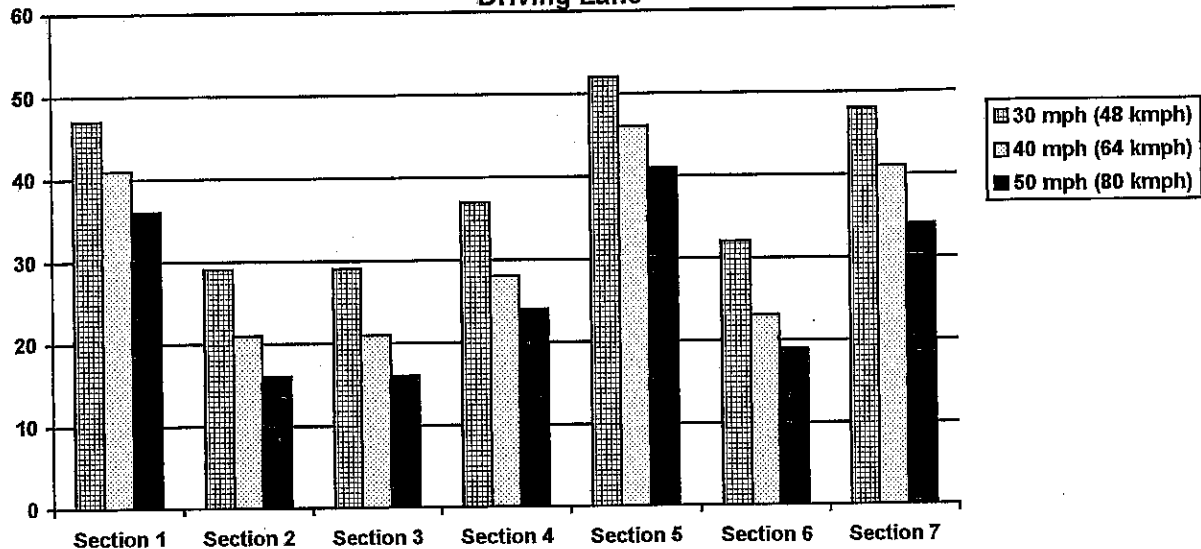
- Test error
- Seasonal variation in precipitation and temperature
- Tire rubber and tread conditions and properties
- Road surface maintenance
- Surface contamination
- Weathering
- Age and traffic
- Aggregate type
- Mix design

### ***Relationship Between Speed and Friction Numbers***

Figures 3 and 4 are graphs of the average treaded tire and smooth tire friction numbers of each texture in October 1979 at 30, 40, and 50 mph (48, 64, and 80 kmph, respectively). These graphs demonstrate the relationship between friction numbers and speed. Refer to Table 1 for the textures corresponding to the designated section numbers at the bottom of the bar graphs.



**Figure 4**  
**Smooth Tire Friction Test Results**  
**for October 1979**  
**Driving Lane**



The friction numbers decreased with increasing speed. As seen in Figure 4, the trend is especially distinct between smooth tire friction numbers and speed. Furthermore, note the greater variance of the smooth tire friction numbers between textures in Figure 4. Once again, the greater sensitivity of the smooth tire to macrotexture is demonstrated.

#### ***How the friction numbers rate according to the IDOT guidelines***

The IDOT guidelines for rating friction numbers are contained in Table 6. Most of the average treaded and smooth tire friction numbers for the seven experimental textures were in the third range of the table ( $F_{n_t} > 35$  and  $F_{n_s} > 25$ ). However, a few of the average friction numbers for the transverse broom, artificial turf, transverse roller, and longitudinal broom sections were in the second range ( $F_{n_t} > 30$  and  $16 \leq F_{n_s} \leq 25$ ). In every test sequence between April 1978 and August 1997, except July 1979, the average friction numbers for the transverse broom, artificial turf, and longitudinal broom sections fell in the second range. However, in July 1979, the average smooth tire friction numbers for those sections were slightly higher, placing the average friction numbers in the third range of the categorical guidelines. In the first test sequence (October 1976), the average friction numbers for the transverse roller section were in the second range ( $31 \leq F_{n_t} \leq 35$  and  $F_{n_s} > 25$ ) but increased to the third range in every test sequence thereafter.

None of the average treaded and smooth tire friction numbers were in the lowest range of friction numbers ( $F_{n_t} \leq 30$  or  $1 \leq F_{n_s} \leq 15$ ). Even if any of the numbers did fall in the lowest range, the

tentative guidelines states, "friction *may* be a factor contributing to wet weather accidents". The higher ranges of friction numbers obviously indicate a lower probability in the role of friction as a factor in wet weather accidents.

**Table 6**  
**Categorical Rating Guidelines for Friction Numbers\***

<b>Range of Friction Numbers</b>	<b>Tentative Guidelines</b>
$F_{n_t} \leq 30$ <b>or</b> $1 \leq F_{n_s} \leq 15$	Friction may be a factor contributing to wet weather accidents
$F_{n_t} > 30$ and $16 \leq F_{n_s} \leq 25$ <b>or</b> $31 \leq F_{n_t} \leq 35$ and $F_{n_s} > 25$	Uncertain if friction is a factor contributing to wet weather accidents
$F_{n_t} > 35$ <b>and</b> $F_{n_s} > 25$	Friction may not be a factor contributing to wet weather accidents

$F_{n_t}$  = Treaded Tire Friction Numbers at 40 mph (64 kmph)

$F_{n_s}$  = Smooth Tire Friction Numbers at 40 mph (64 kmph)

\*Data Source: *Testing Pavement Friction (PTA 96-4)*, Illinois Department of Transportation, Bureau of Materials and Physical Research



## SUMMARY AND CONCLUSIONS

In August 1976, a continuously reinforced concrete (CRC) pavement project on I-72, east of Springfield, Illinois, was textured with various pieces of equipment mounted to a texturing/curing machine. The project was divided into the following seven sections of textures: transverse tines, transverse broom, artificial turf, transverse roller, artificial turf and transverse tines combination, longitudinal tines, and longitudinal broom. From October 1976 to October 1979 (36 months), a testing program was conducted to collect the following measurements: friction numbers, speed gradient, texture depth, internal and external vehicle noise level, and pavement smoothness. In August 1997, friction numbers were again measured on the I-72 experimental sections just before the surface was overlaid with bituminous surface course. This report compares the results of the friction tests during the years that the pavement was tested.

Average treaded and smooth tire friction numbers for each date of testing are presented in Figures 1 and 2. While treaded tire data was collected throughout the testing program (1976 - 1997), smooth tire data was only collected after 1977. Relative ratings of the average treaded and smooth tire friction numbers are presented in Tables 4 and 5. Graphical representations of the average friction numbers for each date of testing except August 1997 are presented in Figures 1 and 2. The treaded tire friction numbers stabilized about a year after the paving project was completed. The decrease in variability between the treaded tire friction numbers of the different textures could be attributed to the changes in the macrotexture and especially the microtexture of the surfaces over time.

During the testing period, the surfaces that provide only microtexture and essentially no macrotexture (the sections finished with the artificial turf or the broom) had relatively low average smooth tire friction numbers (20 - 30). The tined sections had higher average smooth tire friction numbers (35 - 55); and the average smooth tire friction numbers for the transverse roller section fell between the smooth tire friction numbers for the other textures (25 - 35).

The average treaded tire friction numbers for the artificial turf with transverse tines section were consistently the highest or second highest during the testing period. The average smooth tire friction numbers for that section were highest in every test sequence. Compared with the friction test results for the other textures, the artificial turf, the longitudinal broom, and the transverse

broom sections were found to be much less reliable in friction measurements. In general, the transversely and longitudinally tined sections were found to give the best results in both treaded and smooth tire friction numbers.

According to the Department's guidelines for rating friction numbers, most of the average friction numbers for the seven experimental textures were in the highest range ( $F_n_t > 35$  and  $F_n_s > 25$ ). For this range, the guideline states that friction may not be a factor contributing to wet weather accidents. Some of the average friction numbers for the transverse broom, the artificial turf, the transverse roller, and the longitudinal broom sections fell in the middle range, where the guideline states "uncertain if friction is a factor contributing to wet weather accidents". However, none of the average friction numbers were in the lowest range of friction numbers, where according to the guideline, friction may be a factor contributing to wet weather accidents.

The following conclusions are made from the friction testing completed on I-72:

1. The artificial turf and transverse tines section was consistently found to have higher friction measurements throughout the testing program.
2. The transversely and longitudinally tined sections were found to have average friction numbers slightly lower than the numbers for the artificial turf and transversely tined section.
3. Throughout the testing program, the transverse broom, the longitudinal broom, the artificial turf, and the transverse roller sections were frequently found to have lower average friction numbers than the tined sections.
4. According to the Department's Categorical Rating Guidelines for Friction Numbers, the average friction numbers for the seven experimental textures fell within ranges that did not indicate friction as a likely factor in wet weather accidents.

## RECOMMENDATIONS

Currently, the Department specifies two types of final finishes for PCC pavements. The Type A final finish is a combination of the artificial turf and transverse tining; Type B is the artificial turf alone. The Type A finish is to be used unless the Type B finish is specified [6]. According to Departmental Policies, the Type A final finish is to be used on highways with posted speed limits in excess of 40 mph (64 kmph). The Type A or the Type B final finish is to be used on highways with posted speed limits not exceeding 40 mph (64 kmph) [7].

According to the findings of this testing program, recommendations regarding the specifications and policies are as follows:

1. The Type A final finish, the combination of the artificial turf and transverse tining, provides increased and consistent friction measurements. The Type A finish should continue to be a standard for texturing PCC pavement surfaces in areas of higher speed limits (over 40 mph). According to friction test results presented in this report, the Type A finish, as compared to the Type B finish, improved smooth tire friction numbers by over 120% at speeds of at least 40 mph (64 kmph).
2. The Type A final finish would also be excellent in areas of high friction demand, such as intersections and other areas where stop and go traffic is prevalent.

Even at 30 mph (48 kmph), the Type A finish (compared to the Type B finish) was found to increase smooth tire friction numbers by an average of 75%. Although the artificial turf and transversely tined texture is the best choice for good friction qualities, all the tined sections provided increased friction. According to data presented in this report, any of the tined textures (compared to the Type B finish) provided an increase in friction for smooth tire friction numbers of 63% at 30 mph (48 kmph), 96% at 40 mph (64 kmph), and 127% at 50 mph (80 kmph). If the Department is seeking to provide the highest skid resistance and safety for vehicles traveling state roadways in Illinois, any one of the tined textures provided increased friction compared to the Type B finish. However, according to the current Department guidelines for friction numbers, the friction numbers for the Type B finish are acceptable. In order to implement any changes regarding the Department's standard policy on PCC pavement finishes, some important issues (i.e. cost and noise) need to be addressed. Those issues are outside the scope of this report.

## REFERENCES

1. J. Davidson, *PCC Pavement Texturing in Illinois*, Illinois Department of Transportation, Bureau of Materials and Physical Research, Physical Research Report No. 74, May 1977, p. 1.
2. P. Dierstein, *A Study of PCC Pavement Texturing Characteristics in Illinois*, Illinois Department of Transportation, Bureau of Materials and Physical Research, Physical Research Report No. 95, February 1982, p. 16.
3. C. Wu and M. Nagi, *Optimizing Surface Texture of Concrete Pavement*, Portland Cement Association, Research and Development Bulletin RD111T, 1995, p. 3.
4. C. Wu and M. Nagi, *Optimizing Surface Texture of Concrete Pavement*, Portland Cement Association, Research and Development Bulletin RD111T, 1995, p. 33.
5. A. Ardani, *Portland Cement Concrete Pavement Texturing Methods*, National Academy Press, Transportation Research Record 1544, 1996, pp. 18 - 19.
6. Illinois Department of Transportation, Standard Specifications for Roads and Bridges, Adopted January 1997, Article 420.11(e)(1).
7. Illinois Department of Transportation, Departmental Policies, Skid-Accident Reduction Program, December 1988.
8. J. Davidson, *PCC Pavement Texturing in Illinois*, Illinois Department of Transportation, Bureau of Materials and Physical Research, Physical Research Report No. 74, May 1977, p. 24.
9. P. Dierstein, *A Study of PCC Pavement Texturing Characteristics in Illinois*, Illinois Department of Transportation, Bureau of Materials and Physical Research, Physical Research Report No. 95, February 1982, p. 24.
10. C. Wu and M. Nagi, *Optimizing Surface Texture of Concrete Pavement*, Portland Cement Association, Research and Development Bulletin RD111T, 1995, pp. 27 - 32.

# **APPENDIX A**

## **Texture Descriptions and Measurements**

## TEXTURE DESCRIPTIONS

### **Transverse Tines**

A metal comb, consisting of spring steel tines, created transverse grooves  $\frac{1}{8}$  in. (3.2 mm) wide and  $\frac{1}{8}$  to  $\frac{3}{16}$  in. (3.2 to 4.8 mm) deep, spaced at  $\frac{1}{2}$  in. (13 mm) center to center.

### **Transverse Broom**

A transverse broom finishing device, consisting of multiple rows of stiff bristles, was used to create striations with depths between  $\frac{1}{16}$  and  $\frac{1}{8}$  in. (1.6 and 3.2 mm).

### **Artificial Turf**

This texture was created by longitudinally dragging an artificial turf made of molded polyethylene with synthetic turf blades. The turf material extended the full width of the pavement. Approximately 2 ft. (0.6 m) of the carpet's length was in contact with the pavement parallel to the pavement centerline.

### **Transverse Roller**

A metal roller created a transverse texture with grooves at 2 in. (50.8 mm) centers,  $\frac{1}{4}$  in. (6.4 mm) wide, and  $\frac{3}{8}$  in. (9.5 mm) deep.

### **Artificial Turf and Transverse Tines**

A single longitudinal pass of an artificial turf followed by a transverse tining comb.

### **Longitudinal Broom**

A broom finishing device (like the transverse broom) was used to create longitudinal striations with depths the same as the transverse broom texture.

### **Longitudinal Tines**

Longitudinal grooves were created with a metal comb (like the comb used for the transversely tined texture). The longitudinal tines had the same dimensions as the transverse tines.

**APPENDIX B**  
**Friction Testing Data 1976 - 1997**

**FRICTION TESTING DATA**  
**1976-1997**

Texture		FN 30 mph (48 kmph)		FN 40 mph (64 kmph)		FN 50 mph (80 kmph)	
		Driving Lane	Passing Lane	Driving Lane	Passing Lane	Driving Lane	Passing Lane
<b>Transverse Tines</b>							
10-5-76	Treaded	79		65		56	
7-18-77	Treaded	62	65	56	58	51	56
10-24-77	Treaded	67	68	61	63	55	59
4-24/25-78	Treaded	61	72	56	66	50	62
4-24/25-78	Smooth	54	61	45	60	35	49
10-10-78	Treaded	57	61	54	56	51	53
10-10-78	Smooth	47	50	39	44	35	40
7-6-79	Treaded	58	61	56	59	52	56
7-6-79	Smooth	54	56	43	53	43	43
10-19-79	Treaded	57	61	53	59	47	54
10-19-79	Smooth	47	56	41	50	36	44
8-13-97	Treaded			54			
8-13-97	Smooth			36			
<b>Transverse Broom</b>							
10-5-76	Treaded	69		61		50	
7-18-77	Treaded	61	66	53	57	45	50
10-24-77	Treaded	62	70	59	64	53	56
4-24/25-78	Treaded	61	73	52	65	45	61
4-24/25-78	Smooth	29	40	21	42	14	21
10-10-78	Treaded	53	61	51	56	46	51
10-10-78	Smooth	25	37	19	26	15	22
7-6-79	Treaded	55	65	52	60	48	54
7-6-79	Smooth	33	37	27	30	22	25
10-19-79	Treaded	53	62	49	60	44	54
10-19-79	Smooth	29	39	21	32	16	24
8-13-97	Treaded			54			
8-13-97	Smooth			23			



**FRICTION TESTING DATA CONTINUED**  
**1976-1997**

Texture	FN 30 mph (48 kmph)		FN 40 mph (64 kmph)		FN 50 mph (80 kmph)	
	Driving Lane	Passing Lane	Driving Lane	Passing Lane	Driving Lane	Passing Lane
<b>Artificial Turf</b>						
10-5-76	68		55		42	
7-18-77	57	64	48	55	40	46
10-24-77	63	65	52	58	49	51
4-24/25-78 Treaded	60	73	51	65	43	54
4-24/25-78 Smooth	33	48	23	38	16	24
10-10-78 Treaded	54	61	49	56	44	49
10-10-78 Smooth	31	45	21	31	16	25
7-6-79 Treaded	58	62	50	60	47	54
7-6-79 Smooth	39	46	27	35	24	26
10-19-79 Treaded	54	64	49	57	44	50
10-19-79 Smooth	29	39	21	26	16	23
8-13-97 Treaded			51			
8-13-97 Smooth			20			
<b>Transverse Roller</b>						
10-5-76	43		32		26	
7-18-77	56	51	46	47	41	40
10-24-77	62	59	54	54	48	45
4-24/25-78 Treaded	60	66	51	60	45	53
4-24/25-78 Smooth	38	47	32	39	20	30
10-10-78 Treaded	56	58	51	52	47	48
10-10-78 Smooth	35	43	27	35	23	28
7-6-79 Treaded	61	60	53	58	48	54
7-6-79 Smooth	43	48	35	39	29	34
10-19-79 Treaded	56	62	51	57	44	50
10-19-79 Smooth	37	46	28	38	24	32
8-13-97 Treaded			53			
8-13-97 Smooth			31			

**FRICTION TESTING DATA CONTINUED**  
**1976-1997**

Texture	FN 30 mph (48 kmph)		FN 40 mph (64 kmph)		FN 50 mph (80 kmph)	
	Driving Lane	Passing Lane	Driving Lane	Passing Lane	Driving Lane	Passing Lane
<b>Artificial Turf and Transverse Tines</b>						
10-5-76	81		71		62	
7-18-77	66	68	62	67	57	63
10-24-77	67	71	64	68	59	64
4-24/25-78 Treaded	63	75	56	71	53	68
4-24/25-78 Smooth	61	71	51	66	47	57
10-10-78 Treaded	57	62	54	60	50	58
10-10-78 Smooth	56	58	48	54	46	51
7-6-79 Treaded	61	62	57	63	53	61
7-6-79 Smooth	60	61	54	60	50	58
10-19-79 Treaded	55	65	53	64	50	60
10-19-79 Smooth	52	62	46	57	41	52
8-13-97 Treaded			57			
8-13-97 Smooth			48			
<b>Longitudinal Broom</b>						
10-5-76	65		52		37	
7-18-77	56	60	49	51	43	46
10-24-77	62	63	57	56	50	49
4-24/25-78 Treaded	61	71	49	62	44	55
4-24/25-78 Smooth	31	42	23	28	14	17
10-10-78 Treaded	55	59	53	53	45	48
10-10-78 Smooth	35	39	21	26	20	21
7-6-79 Treaded	60	63	53	61	48	56
7-6-79 Smooth	36	38	28	26	20	21
10-19-79 Treaded	54	63	50	55	46	51
10-19-79 Smooth	32	42	23	30	19	25
8-13-97 Treaded			48			
8-13-97 Smooth			24			

**FRICTION TESTING DATA CONTINUED**  
**1976-1997**

Texture	FN 30 mph (48 kmph)		FN 40 mph (64 kmph)		FN 50 mph (80 kmph)	
	Driving Lane	Passing Lane	Driving Lane	Passing Lane	Driving Lane	Passing Lane
<b>Longitudinal Tines</b>						
10-5-76	66		53		45	
7-18-77	61	62	54	54	47	48
10-24-77	64	64	58	59	54	52
4-24/25-78 Treaded	61	70	53	65	48	58
4-24/25-78 Smooth	56	64	36	48	38	41
10-10-78 Treaded	56	58	52	54	49	49
10-10-78 Smooth	54	47	40	39	35	31
7-6-79 Treaded	61	62	59	59	52	57
7-6-79 Smooth	53	59	49	50	39	43
10-19-79 Treaded	58	60	55	56	49	50
10-19-79 Smooth	48	50	41	40	34	31
8-13-97 Treaded			58			
8-13-97 Smooth			38			

**APPENDIX C**  
**1997 Friction Testing Data**

**1997 FRICTION TESTING DATA**  
8/13/97

**I. Transverse Tines**

**Treaded Tire**

Log Mile	Friction Number	Remarks
0.00	47	
0.15	56	
0.29	55	
0.45	57	
0.60	57	
<b>Average</b>	54.4	
<b>Sample Variance</b>	17.8	
<b>Standard Deviation</b>	4.2	

**Smooth Tire**

Log Mile	Friction Number	Remarks
0.07	43	
0.22	29	
0.37	42	
0.53	40	
0.67	25	
<b>Average</b>	35.8	
<b>Sample Variance</b>	67.7	
<b>Standard Deviation</b>	8.2	

**II. Transverse Broom**

**Treaded Tire**

Log Mile	Friction Number	Remarks
0.00	50	Run 1
0.15	57	
0.29	58	
0.44	50	
0.00	50	Run 2
0.18	55	
0.33	55	
<b>Average</b>	53.6	
<b>Sample Variance</b>	12.3	
<b>Standard Deviation</b>	3.5	

**Smooth Tire**

Log Mile	Friction Number	Remarks
0.07	21	Run 1
0.22	23	
0.36	23	
0.11	23	Run 2
0.25	24	
0.40	24	
<b>Average</b>	23.0	
<b>Sample Variance</b>	1.2	
<b>Standard Deviation</b>	1.1	

**III. Artificial Turf**

**Treaded Tire**

Log Mile	Friction Number	Remarks
0.13	49	Run 1
0.27	54	
0.42	50	
0.00	50	Run 2
0.14	52	
0.29	51	
<b>Average</b>	51.0	
<b>Sample Variance</b>	3.2	
<b>Standard Deviation</b>	1.8	

**Smooth Tire**

Log Mile	Friction Number	Remarks
0.00	22	Run 1
0.20	18	
0.35	21	
0.49	22	
0.07	17	Run 2
0.22	20	
0.37	21	
<b>Average</b>	20.1	
<b>Sample Variance</b>	3.8	
<b>Standard Deviation</b>	2.0	

**1997 FRICTION TESTING DATA CONTINUED**  
**8/13/97**

**IV. Transverse Roller**

**Treaded Tire**

Log Mile	Friction Number	Remarks
0.00	53	Run 1
0.15	54	
0.00	53	Run 2
0.14	54	
0.05	53	Run 3
<b>Average</b>	53.4	
<b>Sample Variance</b>	0.3	
<b>Standard Deviation</b>	0.5	

**Smooth Tire**

Log Mile	Friction Number	Remarks
0.08	27	Run 1
0.07	29	Run 2
0.00	34	Run 3
0.00	34	Run 4
0.07	30	
<b>Average</b>	30.8	
<b>Sample Variance</b>	9.7	
<b>Standard Deviation</b>	3.1	

**V. Artificial Turf and Transverse Tines**

**Treaded Tire**

Log Mile	Friction Number	Remarks
0.00	56	Run 1
0.14	59	
0.29	55	
0.43	56	
0.09	58	Run 2
0.24	58	
0.38	59	
<b>Average</b>	57.3	
<b>Sample Variance</b>	2.6	
<b>Standard Deviation</b>	1.6	

**Smooth Tire**

Log Mile	Friction Number	Remarks
0.07	48	Run 1
0.21	41	
0.36	56	
0.00	48	Run 2
0.18	43	
0.31	50	
<b>Average</b>	47.7	
<b>Sample Variance</b>	28.3	
<b>Standard Deviation</b>	5.3	

**VI. Longitudinal Broom**

**Treaded Tire**

Log Mile	Friction Number	Remarks
0.07	50	Run 1
0.22	48	
0.00	45	Run 2
0.16	51	
0.00	43	Run 3
0.14	50	
<b>Average</b>	47.8	
<b>Sample Variance</b>	10.2	
<b>Standard Deviation</b>	3.2	

**Smooth Tire**

Log Mile	Friction Number	Remarks
0.00	24	Run 1
0.15	22	
0.09	26	Run 2
0.22	25	
0.07	23	Run 3
0.21	23	
<b>Average</b>	23.8	
<b>Sample Variance</b>	2.2	
<b>Standard Deviation</b>	1.5	

# 1997 FRICTION TESTING DATA CONTINUED

8/13/97

## VII. Longitudinal Tines

### Treaded Tire

Log Mile	Friction Number	Remarks
0.10	61	
0.25	59	
0.40	57	
0.55	56	
0.70	58	
Average	58.2	
Sample Variance	3.7	
Standard Deviation	1.9	

### Smooth Tire

Log Mile	Friction Number	Remarks
0.00	27	
0.18	40	
0.33	36	
0.48	38	
0.62	50	
Average	38.2	
Sample Variance	68.2	
Standard Deviation	8.3	

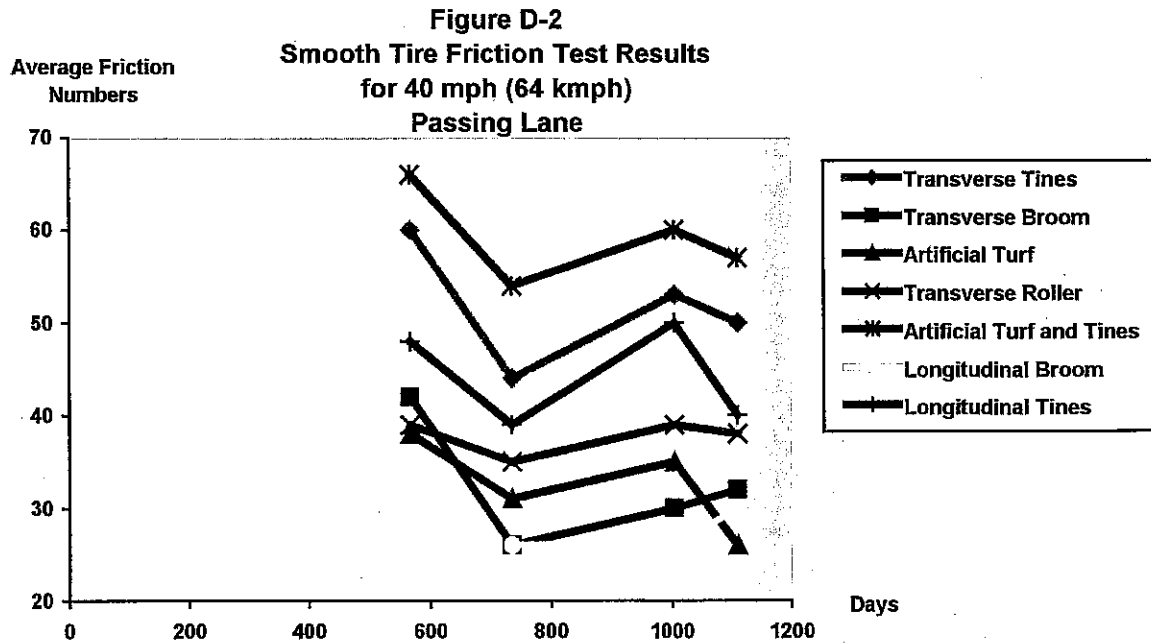
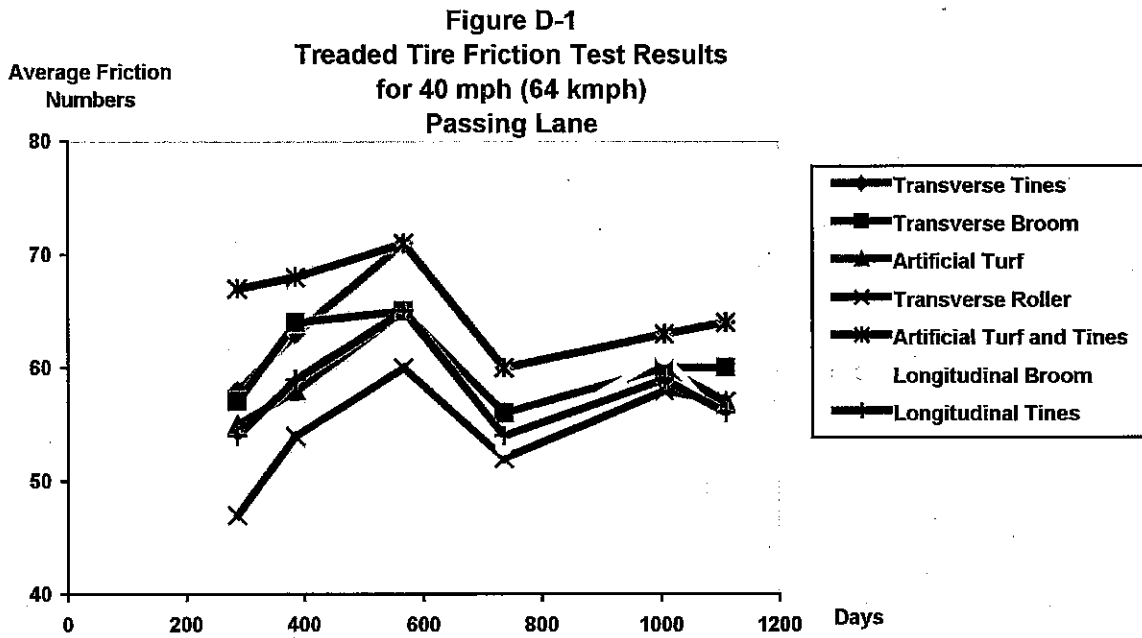
**APPENDIX D**

**Figures D1 – D4: Friction Test Results**



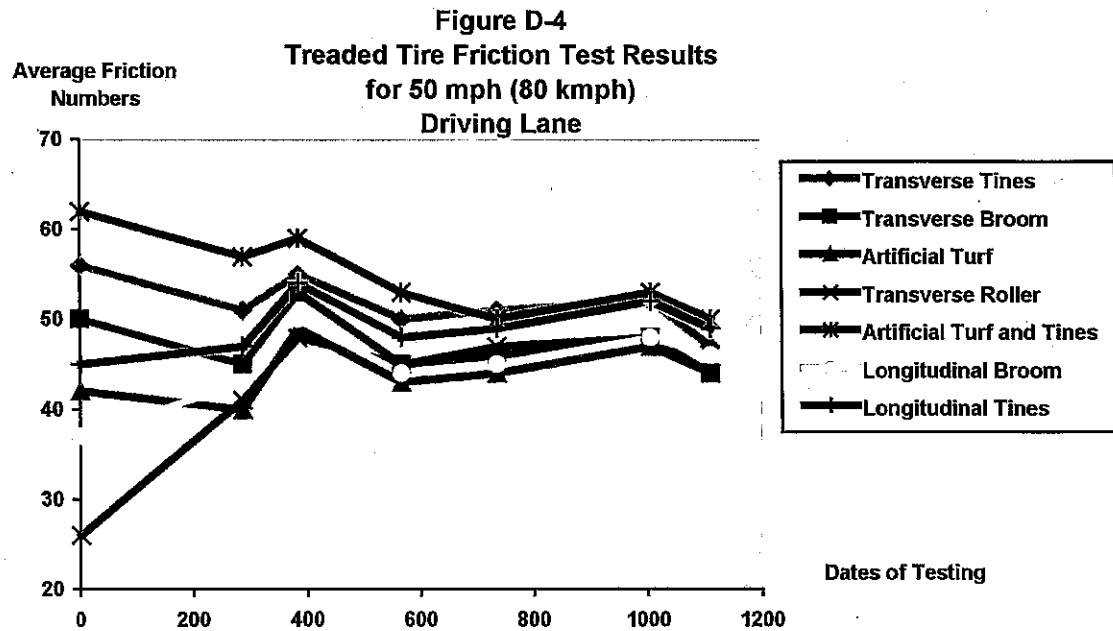
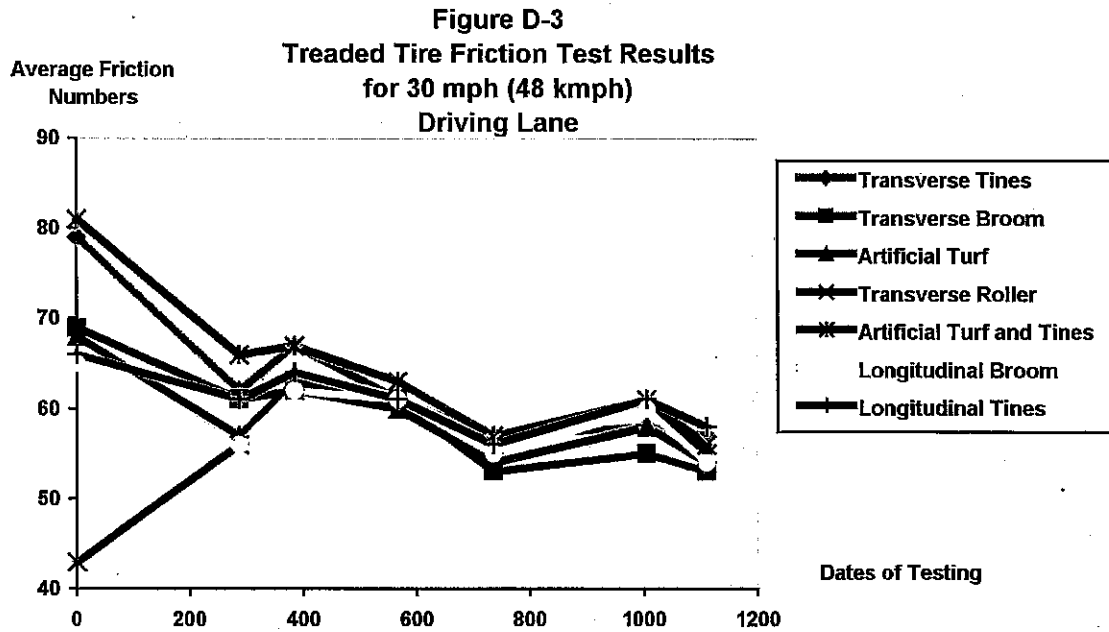
**Friction Test Results  
Figures D1 – D2**

# **FRICTION TEST RESULTS** **FIGURES D-1 - D-2**



## **Friction Test Results Figures D3 – D4**

# **FRICTION TEST RESULTS CONTINUED** **FIGURES D-3 - D-4**



**APPENDIX E**  
**Traffic Data for I-72 (1976 – 1997)**

**TRAFFIC DATA FOR I-72**  
**1976 - 1997**

<b>Beginning Mile Post</b>	<b>Ending Mile Post</b>	<b>Year</b>	<b>ESALs</b>	<b>Cumulative ESALs</b>	<b>Average Daily Traffic</b>	<b>Average Daily Total Traffic</b>
104	108.6	76	262,395	262,395	7100	2100
104	108.6	77	253,592	515,987	7100	2050
104	108.6	78	242,507	758,494	7100	2000
104	108.6	79	231,422	989,916	7100	1950
104	108.6	80	235,813	1,225,729	6900	1150
104	108.6	81	235,801	1,461,530	6670	1150
104	108.6	82	237,114	1,698,644	6845	1175
104	108.6	83	301,743	2,000,387	7000	1200
104	108.6	84	301,750	2,302,137	7150	1200
104	108.6	85	301,757	2,603,894	7300	1200
104	108.6	86	301,764	2,905,658	7450	1200
104	108.6	87	301,772	3,207,430	7600	1200
104	108.6	88	377,452	3,584,882	9250	1600
104	108.6	89	410,420	3,995,302	9600	1725
104	108.6	90	443,387	4,438,689	9950	1850
104	108.6	91	476,355	4,915,044	10,300	1975
104	108.6	92	509,315	5,424,359	10,500	2100
104	108.6	93	529,967	5,954,326	10,701	2276
104	108.6	94	550,635	6,504,961	11,250	2450
104	108.6	95	571,304	7,076,265	11,801	2626
104	108.6	96	591,968	7,668,233	12,272	2800
104	108.6	97	609,733	8,277,966	12,764	2885